United States Department of Agriculture
Forest Service
**Technology &
Development Program**

Dec 2000 *MTDC*

Project Report

7100

Comparison of GPS Receivers Under a Forest
Canopy with Selective Availability Off

ROUGH DRAFT

Dick Karsky, Project Leader; Ken Chamberlain, Land Surveyor; Santiago Mancebo, Graduate Student USFS Volunteer; Don Patterson, Land Surveyor; and Tony Jasumback, GPS Consultant

Table of Contents

Comparison of GPS Receivers Under a Forest Canopy with Selective Availability Off

Tests – Summer 2000

SA-off

On May 1st President Clinton announced that Selective Availability (SA) would be turned off effective midnight May 1, 2000. This degradation feature Selective Availability (SA) is the intentional degradation of the Global Positioning System (GPS) signals. This will mean that civilian users of GPS will be able to pinpoint locations up to ten times more accurately than before. With SA off position accuracy in the autonomous mode increased from +/- 100 meters to less than +/- 10 meters (see Figure 1). The decision to discontinue SA is the latest measure in an on-going effort to make GPS more responsive to civil and commercial users worldwide. Last year, Vice President Gore announced plans to modernize GPS by adding two new civilian signals to enhance the civil and commercial service.

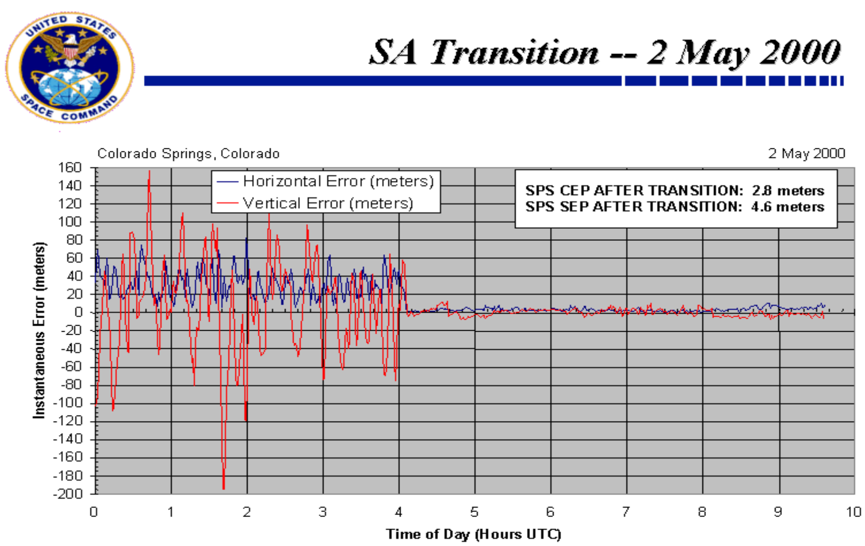

Figure 1. The change in position error when SA turned off

Test courses

Powell, Idaho GPS test course

This GPS test site is located on the Powell RD on the Clearwater NF. It is located on Highway US 12 near the Idaho Highway Maintenance area about 12 miles west of Lolo Pass and about 55 miles SW of Missoula, MT. The test site is located near the Lochsa River, and has mountains on the north and south sides of the course, with a obstructed angle of 10 degrees on those two sides. The canopy consists of large (24”-42” d.b.h.) old growth Cedar and Spruce trees in a flat valley bottom with only a small amount of understory and would be considered a heavy canopy at most of the stations. The course has 11 turning points or stations, making a polygon measuring 12.019 acres in size that can be divided to produce 2 areas (see Figure 2).

The ground survey traverse and geodetic control survey of the Powell, ID GPS test course was done by R-1 engineering and the Cadastral Survey group, Lolo N.F for MTDC. The conventional survey was accomplished with a Topcon total station. The GPS control survey was accomplished with four Trimble 4000SSE/SSI geodetic GPS receivers with L1/L2 compact dome geodetic antennas operating in the static mode. Three data sets were observed from HARN (High Accuracy Reference Network) stations “LOLO GPS” and “W522”. Final results were calculated from a least squares adjustment utilizing fixed integer baselines from the geodetic observations. GEOID99 model was used for geoid separation estimates. The error estimates for the network observations are in the 2-centimeter range. Coordinates are NAD83 (1992) Montana HARN Latitude, Longitude.

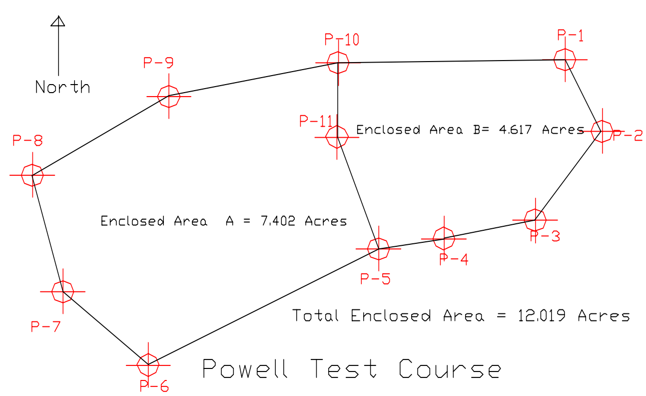

Figure 2. Site Diagram for Powell GPS test course

Lubrecht Test Course

The Lubrecht Test Course is located at the Lubrecht Experimental Forest about 30 miles NE of Missoula, MT. This course is a polygon with seven turning points (stations) and is located on gentle terrain, under a mixed Lodgepole and Ponderosa Pine canopy. The trees are about 19 meters tall with a minimal understory and would probably be classified as a light to medium canopy. Station B-31 is located in the open, with a clear view of the sky down to an angle of 15 degrees (See Figure 3).

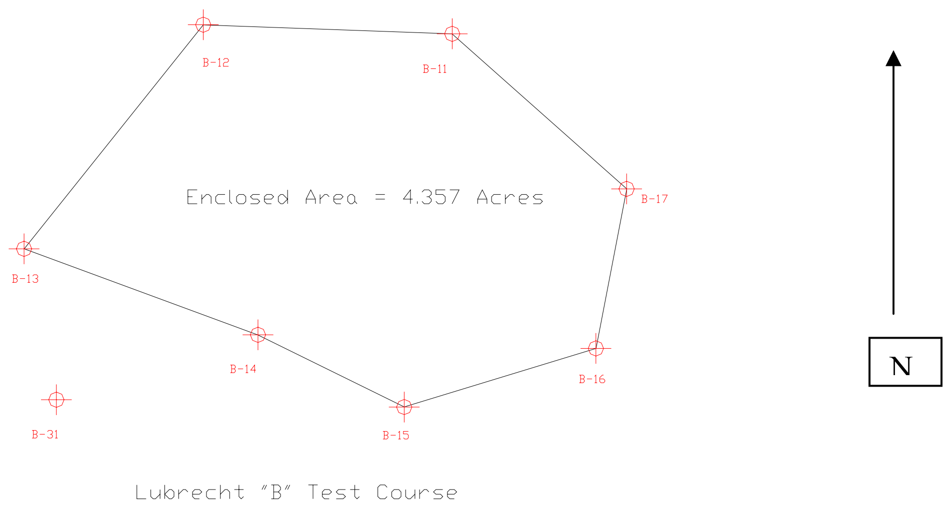

Figure 3. Site Diagram for Lubrecht GPS Test Course

Clackmas test course

The Pacific Northwest Regional Surveyor established a test course at the request of the Forest Service's GPS Steering Group in a typical dense West Coast Douglas-fir stand. The course is on gentle terrain in a second growth Douglas-fir and western hemlock overstory (trees approximately 24 to 40 inches d.b.h.) with a vine maple and red alder understory. It consists of 13 stations, all accurately located within 0.05 meters. The area enclosed by the traverse can be varied from 2.19 to 7.20 acres, depending on the stations chosen (see Figure 4).

The Test Network geographic positions were established by GPS and conventional geodetic survey. These thirteen points are used to define five areas, which range from 2.19 to 7.20 acres. Geographic positions for the network points are accurate to 5 cm. Each point is monumented with 5/8" rebar with plastic caps and a nearby orange carsonite fence post, with "survey monument" sticker attached. All points are intervisible and the lines between the survey points are brushed and flagged.

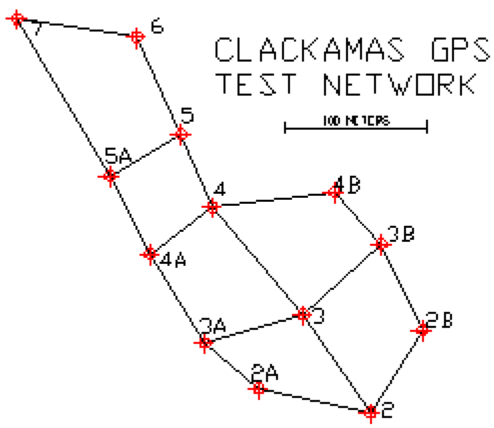

Figure 4. Site Plan for Clackmas GPS Test Course

Test procedure

The receivers were turned on and allowed to collect data for approximately 20 minutes to insure that a current almanac was stored in the receiver before the tests were run. External antennas were used on all receivers for most of the tests. Some tests were run with the built-in internal antennas to obtain a comparison between the 2 types of antennas. Different numbers of positions (1, 60, and 120) were averaged at the different stations to determine what affect that had on the accuracy. When possible the PDOP (Precision Dilution of Precision) and EPE (Estimated Position Error) values were monitored to determine what type of constellation was being accessed by the receivers. The position errors obtained at each station were then averaged over the complete course to determine the average error of the individual receiver.

Receivers tested

The receivers tested on the Lubrecht and Powell courses were:

1. Rockwell PLGR-96, PPS, S/N 165268, with sw:613-9868-015 Software.
2. Trimble Pro XR, S/N 0220174140 with TSC1, and Asset Surveyor Ver. 5.00 software.
3. Trimble GeoExplorer 3, S/N 0330040826, with Ver. 1.02 Firmware.
4. Magellan Map 410 Receiver Ver. 1.05 Firmware
5. Garmin GPS III, S/N 92113388, 2.05 Firmware

PLGR +96

The PLGR+96 FED is a five-channel, single-frequency Precise Positioning System (PPS) P(Y) Code receiver with built-in antenna. It has been evaluated in other MTDC reports and the accuracy of the receiver hasn’t changed significantly with S/A turned off. The receiver contains a security module that can eliminate the positional error intentionally introduced when selective availability (SA) was enabled and it decodes the encrypted signal, which prevents its unauthorized use, called anti-spoof (AS). The receiver is not classified, but it is an accountable property item and should remain in control of the authorized user. It can store 999 waypoints and has 15 user definable reversible routes that can have up to 25 legs each. It has an external power and antenna option. It is DGPS ready.

Garmin GPS III+

The Garmin GPS III is a Differential-ready 12 parallel channel receiver that continuously tracks and uses up to twelve satellites to compute and update a position. It has acquisition Times of, approx. 15 seconds warm and approx. 45 seconds cold. It has a continuous update rate of 1 second. It can store 500 waypoints with symbols and 20 reversible routes, and a track log of 1900 points. It has a built-in detailed basemap that covers lakes, rivers, interstates, national/state highways, secondary roads in metro areas, cities, railroads, airports and a detailed exit database for the Federal Highway system). More detailed maps are an option. It has 106 different map datums. It has a NMEA 0183 and RTCM 104 DGPS corrections interface. It has an optional external antenna.

Trimble Pro XR

The Trimble Pro XR is a 12-channel, real-time differential GPS receiver with an integrated antenna. The antenna receives the GPS signal and the real-time differential corrections broadcast by a radio beacon maintained by the U.S. Coast Guard or the U.S. Army Corps of Engineers. The operator can select if DGPS is to be used and which real-time broadcast station to use. It is capable of outputting both the real-time differentially corrected position as well as the raw data for each position. Data were collected using the Trimble System Controller (TSC1) data logger with Asset Surveyor Software Version 5.00 The data collection interval was set at 1 second, with the PDOP and SNR masks set at 6, and the elevation mask set at 15. Pathfinder Office Software Version 2.70 was used to differentially post process the raw-position data and display both the post processed and real-time-corrected position data. Base-station data for post processing were obtained from the Forest Service base station in Missoula for the Powell and Lubrecht Site. (h*ttp://www.fs.fed.us/database/gps/missoula.htm*). That station, was a About 30 miles from the Lubrecht Site and about 55 miles from the Powell test site, and records data at 5-second intervals.

Trimble Geo 3

The GeoExplorer 3 receiver is small in size, and its portability and powerful features make the GeoExplorer 3 an ideal tool for creating and maintaining utility, urban and natural resource asset databases. It has an integrated, high-performance 12-channel GPS receiver and antenna. The receiver firmware provides for easy GIS data collection, easy data maintenance of existing GIS databases, cable-free real-time differential GPS with Beacon-on-a-Belt receiver and it provides ARC/INFO, AutoCAD, Intergraph, MGE, ERDAS and GRASS support. GPS Pathfinder Office software is included for data processing and GIS export.

Magellan Map 410

The Magellan Map 410 is a 12 parallel-channel receiver with a detachable signal-sensitive antenna. It has a built-in worldwide background map and detailed basemap for the Americas includes cities, lakes, rivers, railroads, coastlines, interstate, national and state highways. It has a built in altimeter. It can store 500 waypoints and 20 routes with 30 legs. It automatically averages your position when the receiver is stationary. It has 9 graphic navigation screens, a re-settable trip odometer, and "EZstart" initialization and built-in simulator for training and education. It has Upload/Download Capability, has NMEA output and is DGPS ready. It has external antenna capability.

Results

Most error results shown in the following charts may be expressed in 2DRMS values. The 2DRMS value approximates the 95% probability of error for a position. This means that 95% of the time or 19 out of 20 position readings will have an error less that what is shown on the charts. The formula used in the calculation of 2DRMS is:

$$2DRMS=2x((\text{Mean Error})^2 +(\text{Standard Deviation of Error})^2)^{0.5}$$

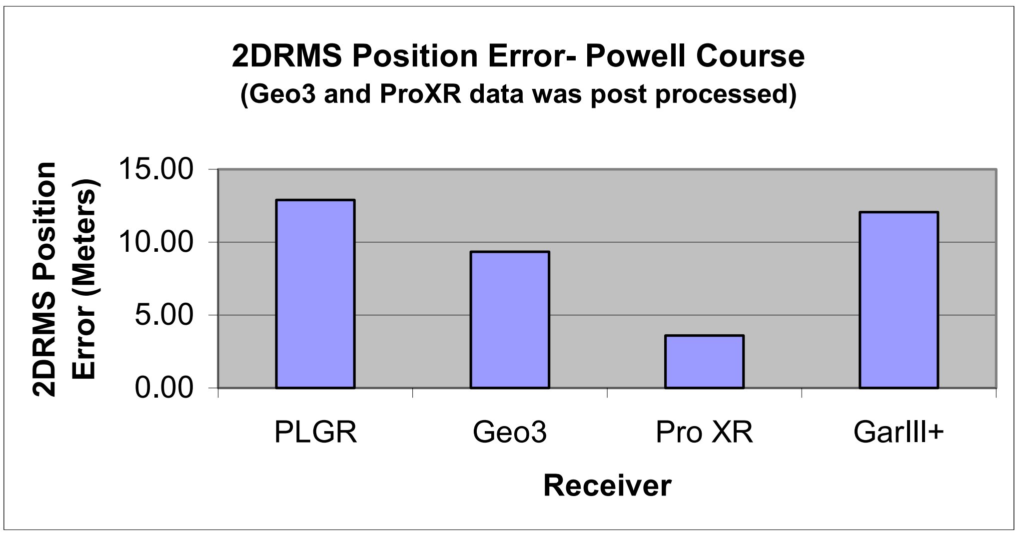

Figure 5. Chart shows the position error in 2DRMS, (95% of the time the error will be less than shown), for the different receivers on the Powell GPS test course. (120 records averaged).

The chart in figure 5 shows the position errors for the different receivers on the Powell test course. The Trimble Pro XR and Geo 3 receivers collected files that could be post-processed and those files were post-processed in figure 5. The error over the course with the Pro XR was often less than 2 meters under the forest canopy. Figure 6 shows position errors for the different receivers on the Lubrecht test course and the Trimble Pro XR and Geo 3 were not corrected or post-processed is this graph. The position errors for the Trimble Pro XR and Geo 3 receivers are more similar to the other receivers compared to figure 5 because of the uncorrected or non-post processed data. Most position errors were less than 7 meters for all receivers except for the Magellan receiver.

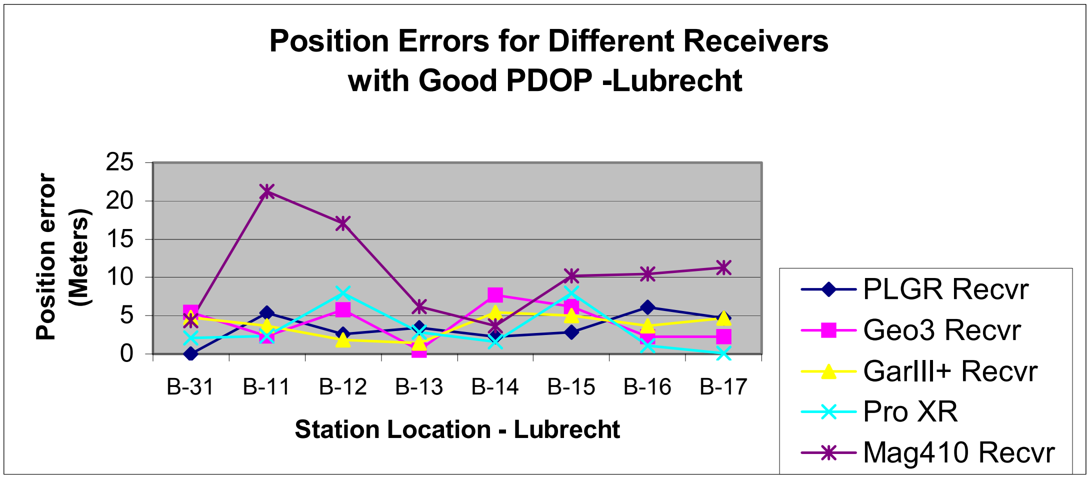

Figure 6. This graph shows the position errors at the different stations for the Lubrecht GPS test Course. In this graph the Pro XR and Geo 3 were not post-processed. (60 record average).

Station 31 is in the open and not under a forest canopy. As can be seen in figure 6, all of the receivers have position errors of less than 5 meters. If all the position records are averaged for all the stations on the course, an overall position error can be determined for each receiver over the complete GPS test course. This is shown in Figure 7.

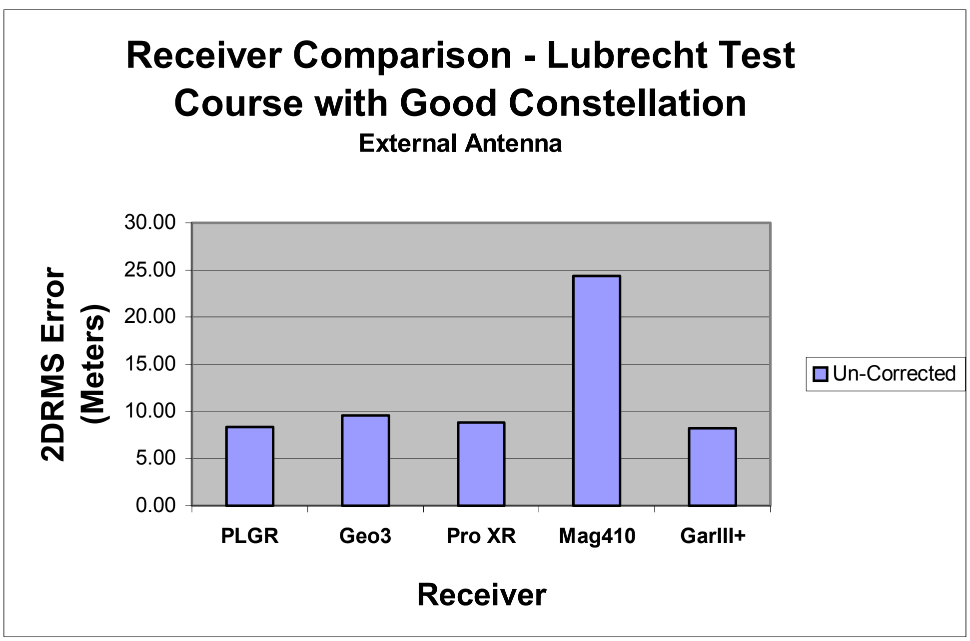

Figure 7. This graph shows the position error for each of the receivers on the Lubrecht GPS test Course. In this graph, all position error records for each receiver, shown in figure 6, were averaged for each station. The position errors for each receiver, on all stations, on the whole course were then averaged to obtain an overall position error for each receiver.

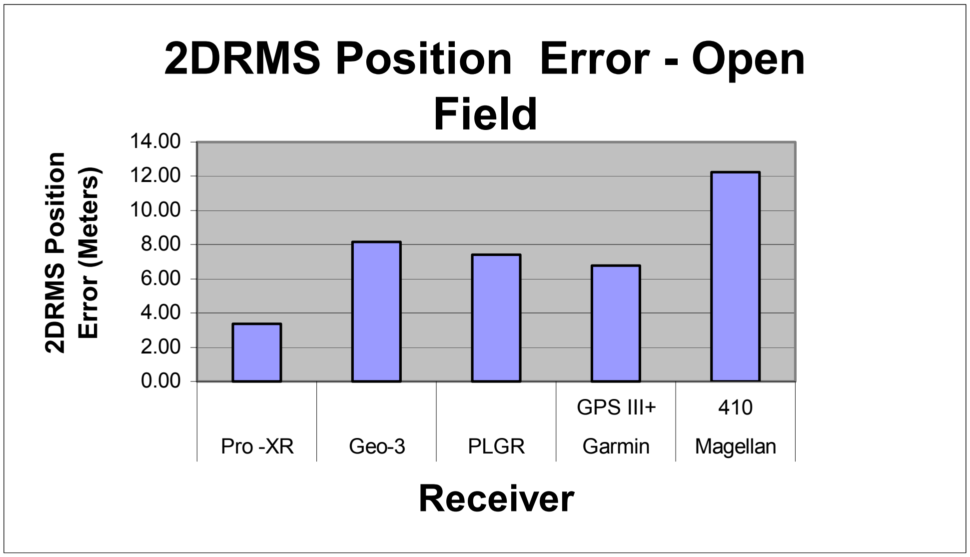

Figure 8. This graph shows the position error for each of the receivers at an open point (no canopy), near the MTDC office. In this graph, the position error was obtained by calculating an average position error for each of the different record sizes (1, 60, and 120 records) in the open. The 2DRMS value was then calculated from those values for each of the receivers.

Post-processing

As previously mentioned, the only receivers that collected data that could be post processed were the Geo 3 and the Trimble Pro XR. Figure 9 and 10 show the results of post processing data from those receivers for the different number of records averaged.

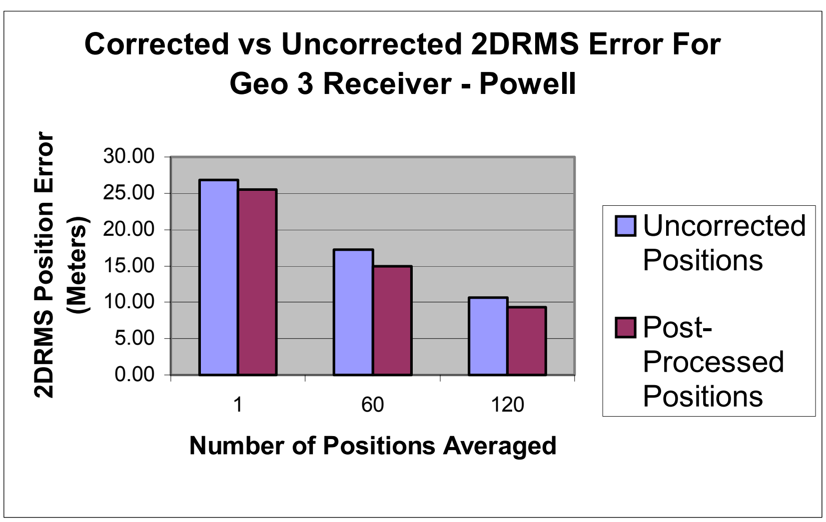

Figure 9. This graph compares the 2DRMS position error for the Trimble Geo 3 receiver when a different number of records are averaged. The files were post-processed and also

displayed on this graph. It shows the potential for large errors if only a few positions are averaged.

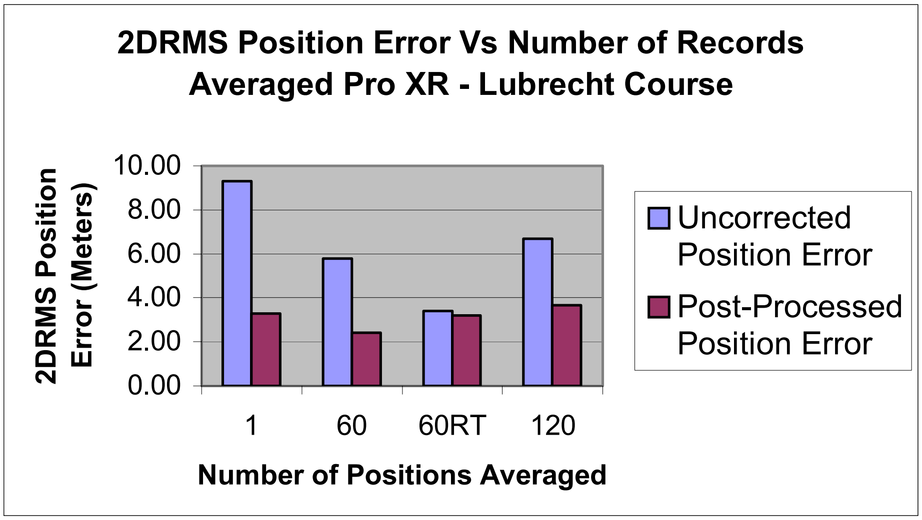

Figure 10. This graph compares the 2DRMS position error for the Trimble Pro XR receiver when a different number of records are averaged. RT indicated real-time corrected positions. The files were post-processed and also displayed on this graph. Why the large error occurred for the 120 record average-uncorrected is unexplainable, but it shows how much of that error was removed by post processing.

Effect of SNR on position accuracy

Figure 11 shows the effect of different SNR (Signal to Noise Ratio) values to position accuracy. As SNR increases so does the accuracy. However, setting the minimum SNR value to a larger value, will normally cause the efficiency of data collection to go down. The higher SNR values usually will require waiting at positions for a longer period of time before the stronger signals will be available to the receiver. Mancebo and Chamberlain have a more detailed discussion of the SNR vs data collection efficiency in another paper.

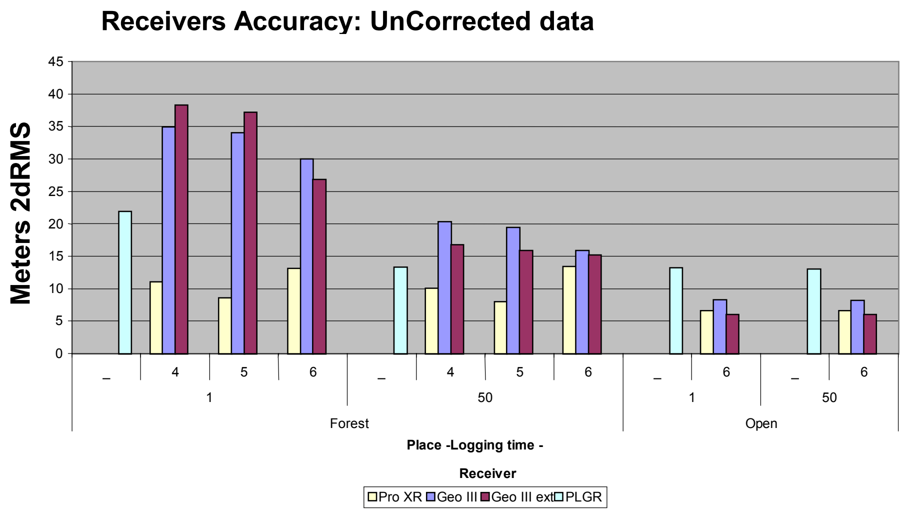

Figure 11. Graph showing the effect of SNR on position accuracy under canopy and in the open for 1 and 50 position records.

Effect of PDOP on Position accuracy

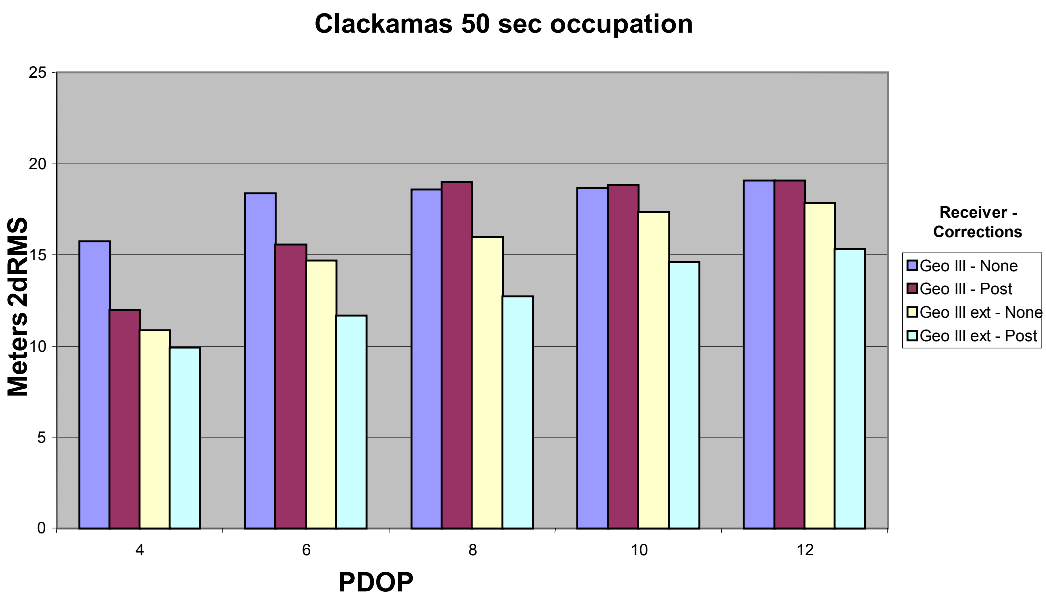

Figure 12: This graph shows the accuracy of various receiver configurations at the forested Clackamas Test Course for 50 seconds of data at various PDOP settings.

As can be seen from figure 12, the accuracy will decrease as PDOP increases. This data was collected on the Clackamas Test Course with the GeoExplorer 3 receiver. The effect of post-processing is also displayed in this graph. Post-processed data collected with a PDOP of 12 was more accurate than uncorrected data with a PDOP of 4.

Effect of using external antennas on the receivers

All but the Trimble Pro XR have internal antennas. In the open, under no tree canopies, the internal antennas are usually adequate. However under the forest canopy, external antennas can give better accuracies. Figure 13 is an example of the improved results for the Garmin GPS III+. The results will differ for the different receivers but the external antennas are more sensitive and are usually placed on a range pole higher than the operator's head thereby reducing signal blockage.

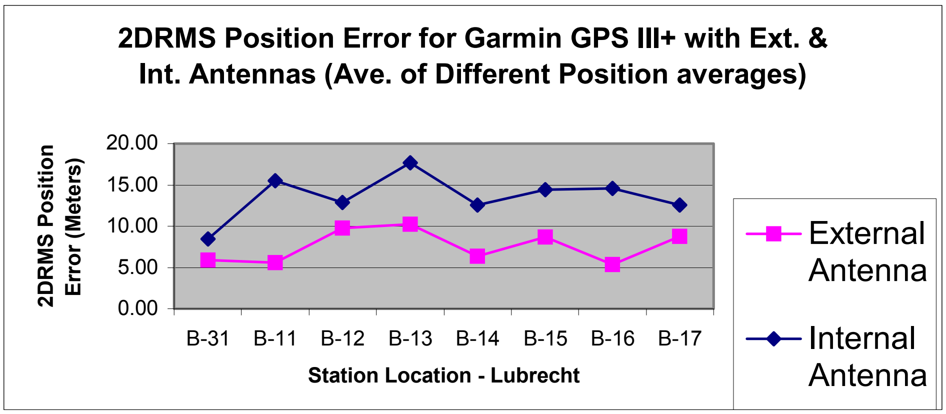

Figure 13. This graph shows the effect of using an internal and external antenna and the effect it has on 2DRMS position accuracy. These values obtained for the different stations are calculated from the different number of position averaged.

PLGR better in canopy

The PLGR acquires positions better in canopy than the C/A code receivers. This is possibly due to the fact that the P(Y) code chipping rate (The frequency at which the P code chip code is transmitted) is an order of magnitude higher than the C/A code. Under an open canopy the accuracy may not be as good as some of the C/A code but is comparable under the canopy. The major advantage to the receiver is that it is simple to use and the data acquisition is much more efficient. However as shown in a later, figure 16, if a poor constellation is being used to calculate a position, a larger position error is obtained.

Real time vs post processed

Real-time positions or DGPS positions are positions that are corrected real time, with correction signals sent to the receiver from a beacon DGPS station or via Satellite from a network of ground stations. These signals are received and the data corrected real-time. Post processing real-time data doesn't significantly increase the position accuracy most of the time but usually does improve it. The "down-side" to real time data collection is that sometimes the correction signal is interrupted or is "attenuated". If the files are collected and brought back to the office, it is usually quicker and more efficient to post process the data later at the office. Figures 14 and 15 show the position error results of Real-Time (DGPS) and post processing data.

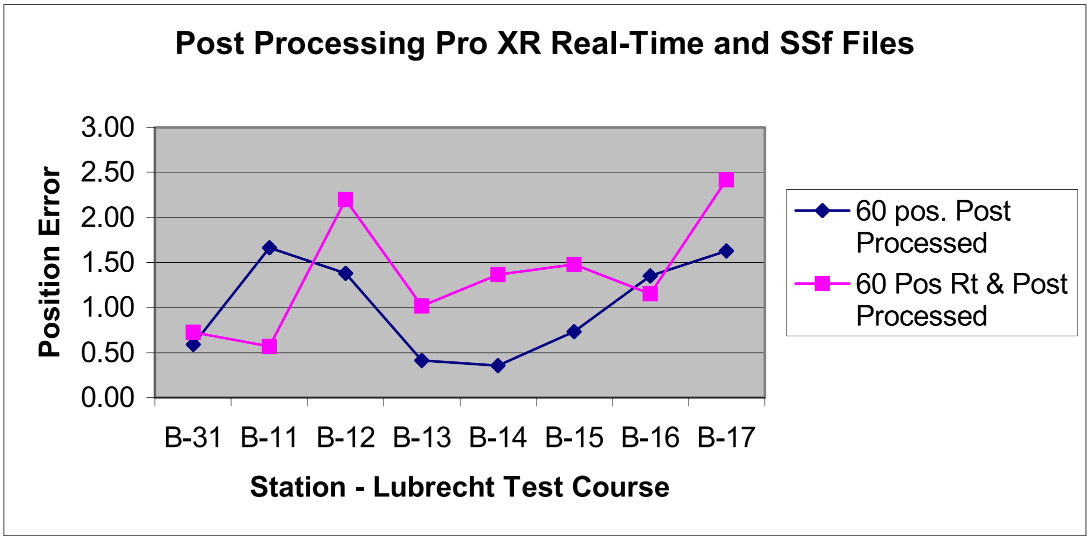

Figure 14. This graph shows the effect of post-processing un-corrected data (ssf) files and post processing real-time corrected data (all data was processed).

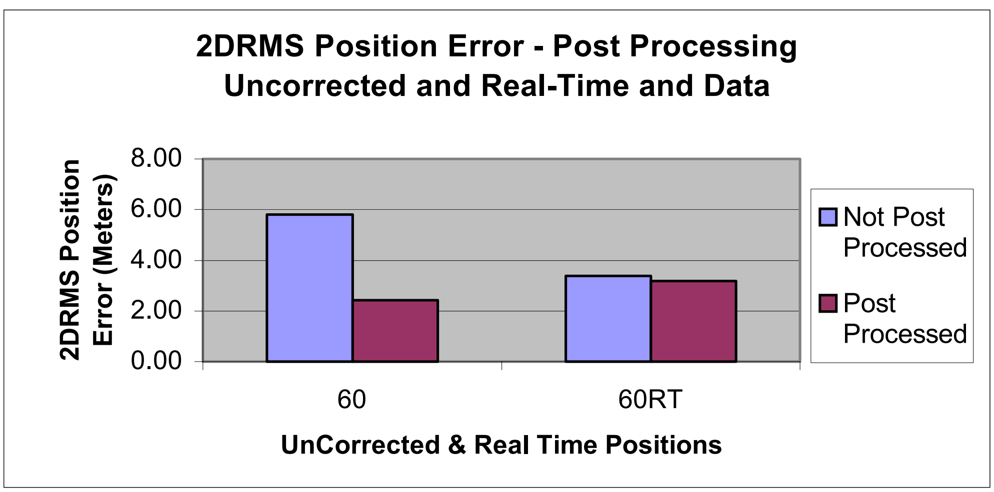

Figure 15. This illustration shows that post processing increases accuracy of the position. This increase is significant for uncorrected data but is very small when post processing real-time data.

Effect of battery voltage

Battery voltage has an effect on PLGR's and Trimble GeoExplorer II's. The symptoms of Trimble Geoexplorer II's and PLGRs with weak batteries are that the receivers will have difficulty acquire a signal or GPS position under canopy. When batteries are replaced, the signal is more easily acquired. The Garmin GPS III+ and Magellan Map 410 were operated until battery low indication on the display panel was received. A position, in open canopy, with low voltage was recorded and then the batteries were replaced, and same positions retaken. The results showed little effect on position error with low and new batteries for those 2 receivers.

Discussion

In some of our tests, the smaller units such as the Garmin GPS III were used as an indicator of satellite constellation. The trend seemed to be that if 6-7 Satellites with good PDOP were displayed on the “skyview” screen, the position accuracy was usually good. The Garmin GPS III+ receivers usually produced good accuracy results. They typically are on par with the Trimble Geo 3's. However if a bad constellation is present, the Garmin will still record data. The Garmin doesn't have a PDOP or SNR mask, and it doesn't have a minimum mask angle (which would reduce the potential for multipath signals to be received by the GPS receiver). If they can see a satellite they will use it in a solution. What was found is that if the receiver is tracking 5-7 satellites with good SNR values on the skyview screen you will probably get accurate results. If you have only 4 or 5 weak satellites the results won't be that good. So with receivers without PDOP and SNR mask, if that is not observed, you may be getting some poor data.

The masks on the Trimble Geo 3 were set to PDOP=16, SNR=2, and Elevation=3 degrees. It was then run on the test course with the PLGR, and Garmin on the Powell course when the satellite constellation was poor (Mission Plan indicated a PDOP > 16 during that time period). We got similar position errors from the PLGR, Garmin, and Geo 3 (Errors greater that 20 meters) and of course the Pro XR was not recording because the masks were set so it would only receive good data These results are shown in figure 16. The Garmin will also record 2-D fixes using only 3 satellites when averaging waypoints and this was being done while these tests were run. We used the Garmin with their external antenna, which did improve accuracy as is illustrated in Figure 13.

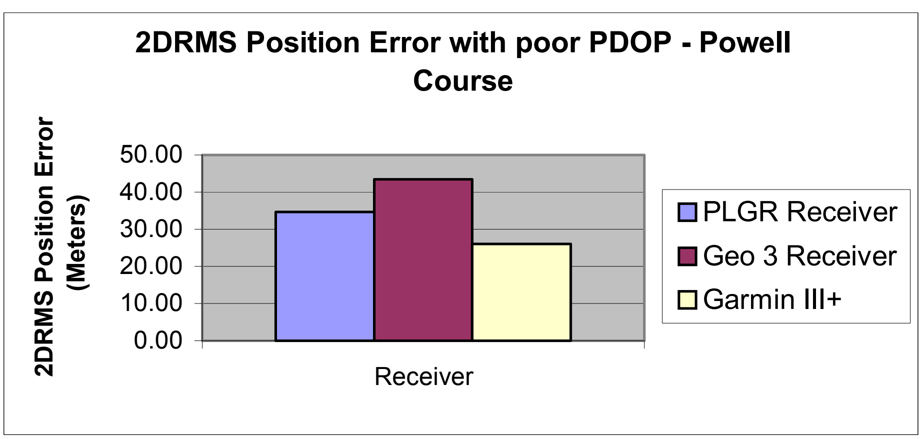

Figure 16. This chart shows position error for three receivers when the satellite constellation was poor. The mission planning software indicated that the maximum PDOP (Position Dilution of Precision) at the time was about 16. The Geo 3 mask settings were changed to allow data to be recorded.

The conclusion is that if the constellation is bad (poor PDOP), position errors will increase and the receivers will record positions even though the EPE (Estimated Position Error) readout has reasonable values. Better receivers have PDOP, SNR, and Elevation Angle masks that will reduce the probability of recording inaccurate data. But with the better accuracy comes the "trade-off" of less efficiency. There will be times when the receiver will have to wait as positions won't be recorded even though it may be tracking 5 or 6 satellites due to poor PDOP.

General comments
Some general comments about the different receivers are:

- The Garmin GPSIII+ is a very user-friendly receiver. It acquired satellite signals quickly, and averaging a waypoint was easy to accomplish. The factory DGPS antenna was not as sensitive as the Trimble and was not able to receive a weak beacon signal when the Trimble Pro XR could acquire one. There is no way to limit the Maximum PDOP setting, the minimum SNR setting or the minimum elevation angle.

- The Magellan Map 410 is also a user-friendly receiver. However averaging a waypoint is tricky because averaging starts as soon as the receiver quits moving. One is never sure if some positions from a few feet away are included in the average. Again the factory DGPS antenna is not as sensitive as the Pro XR.

- The Trimble Pro XR is very easy to use and it will inform you if a beacon station is available for Real-Time DGPS. It gives information about that beacon signal, i.e. signal strength, frequency, bit rate, and more. Under a difficult canopy, it seems to take time to acquire a satellite signal and a position. This is due to the receiver mask settings, of PDOP, SNR, and Elevation angle. It appears that the other receivers are more sensitive and are more efficient but in reality, the data received is not very good data and when comparing position accuracy, the Pro XR gives better results.

- The Trimble Geo 3, with the internal antenna, does not obtain positions as accurate as the Pro XR and sometimes the other receivers. Using an external antenna will provide a big accuracy improvement for this receiver.

- The PLGR is an "older technology" receiver, which in the open, may not be as accurate as the newer receivers. It will acquire a signal under a dense canopy easier that most of the C/A code receivers. It is easy to use but requires "Keying" (Keying is inserting a code in the receiver to eliminate selective availability (SA) and must be done annually). Previous to these tests two

PLGR receivers were compared on the Lubrecht test course, one keyed with the P(Y) code and the other with the P(Y) code "zeroized" (zeroized means the P(Y) code was removed and the receiver could only receive the C/A civilian code) and the results compared. The P(Y) code version provided smaller position errors.

Summary

In summary a good constellation is needed to get good data. If data is recorded, it will record positions with more error. The small handheld inexpensive receivers will provide accurate positions in the open and under a medium canopy when good PDOP is available, but that may not be the case under heavy canopy or when the satellite constellation is poor (poor PDOP).

Post processing data still increases position accuracy, typically 2 – 4 meters. If data isn't needed immediately it is easier and more efficient to collect data (ssf files) and post process the information rather than trying to collect real-time DGPS positions. This may change in the future when more real-time DGPS stations come on line and all areas have double coverage (when a location can receive a real-time DGPS signal from 2 different beacon stations).

A report written by Santiago Mancebo and Ken Chamberlain discuss the results of the effects of SNR and PDOP on position accuracy for these receivers and what effect they have on data acquisition efficiency. This study was done on the Clackmas Test Course, which has a heavy forest canopy and is similar to the Powell GPS Test course.

Further work that should be done is:

- What is the correlation if any, between the EPE value indicated on the GPS receiver and the real error?
- More testing of the DGPS real-time accuracy of the different receivers and the efficiency of collecting DGPS data.
- More tests of how much post processing improves the accuracy of DGPS real-time positions.
- The newer PLGR II, dual frequency receiver should be evaluated.

Appendix A: Summary Table of Different GPS Receivers

Receiver	Advantages	Disadvantages	Accuracy (Typical)	Approx. Cost
Trimble Pro XR	• Can log Data • Can Post Process • Can export data to Arc/Info • Real-Time DGPS • Accuracy	• Cost • Bulky	Open Canopy 1-4 m Under Canopy 2 – 5 m	$10,000
Trimble Geo 3	• Can log Data • Can Post Process • Can export data to Arc/Info • Real-Time DGPS	• Cost • Not as accurate as Pro XR • Should use External antenna	Open Canopy 1-4 m Under Canopy (120 positions) Lubrecht 2.4 – 7.7 m Post-Processed 2.5 – 7.8 m	$4,500
Rockwell PLGR	• Acquires GPS Signal in difficult canopy and terrain better than C/A signal • Simple to Use	• Must record positions manually. Doesn't log data without external data logging device. • Can't Post Process • Can do Real-Time processing but then uses the C/A signal. • Accuracy not as good as post processed other receivers. • A military accountable item. • Must be re-keyed annually.	Open Canopy 1-4 m Under Canopy (120 positions) Lubrecht 2.5 – 6 m	$3,500 Ext. Ant. +$300
Trimble Centurion	• Acquires GPS Signal in difficult canopy and terrain better than C/A signal • Simple to Use	• Can use Asset surveyor software and TDC1 data logger to collect data. • Can't Post-Process	Open Canopy 1-4 m Under	$4,900 Ext. Ant. +$300

		"P" code data. • Can do Real-Time processing but then uses the C/A signal. • Accuracy not as good as post processed other receivers. • A military accountable item. • Must be re-keyed annually.	Canopy (120 positions) Lubrecht 2.5 – 6 m	
Garmin III+	• Cost • Ease of Use • Readily available • Records Waypoints and can download to their software • Can do Real-Time DGPS with extra optional receiver with some work • Can Average Waypoints	• Can't export data into ARC/Info • Can't Post Process • Should use External antenna	Open Canopy 1-3 m Under Canopy (Ave 120 positions) 2.5 – 5 m	$350-Unit Soft. & Ext. Ant +$200 DGPS +$300
Magellan 400	• Cost • Ease of Use • Readily available • Records Waypoints and can download to their software • Can do Real-Time DGPS with extra optional receiver with some work • Can average waypoints	• Can't export data into ARC/Info • Can't Post Process • Should use External antenna • Waypoint Averaging is tricky – starts when receiver quits moving	Open Canopy 2-7 m Under Canopy Lubrecht (60 position average) 3 – 12.2 m	$350 - Unit Software $60+ Ant $100

Table 1. **Comparison of various Receivers** ***Preliminary only***

About the Authors

Dick Karsky has a bachelor's degree in agricultural engineering from North Dakota State University and a Masters degree in agricultural engineering from the University of Minnesota. He worked as a project leader in most resource areas in the USDA Forest service since coming to the Missoula Technology and Development Center in 1977 and had been involved in the GPS program since 1996. His current position is Program Leader in Forest Health and in Water, Soil and Air.

Tony Jasumback, is a retired MTDC -USFS employee and was the GPS Project Leader at MTDC, and was involved in the development and evaluation of GPS equipment for Forest Service use since 1984.

Ken Chamberlain, is a cadastral surveyor for the USFS at the Regional Office in Region6 at Portland OR.

Santiago Mancebo, is a Graduate student from Spain and USFS Volunteer employee

Don Patterson is a land surveyor in the Northern Region Engineering Office in Missoula, MT. He is a licensed land surveyor in Wyoming and Montana. He holds a bachelor's degree in surveying from the Oregon Institute of Technology. Don worked for the BLM in Alaska and Wyoming before coming to the Northern Region.

Single hard copies of this document may be ordered from:
USDA Forest Service
Missoula Technology & Development Center
Building 1, Fort Missoula
Missoula, MT 59804-7294
Phone: (406) 329-3978
Fax: (406) 329-3719

E-mail: pubs_wo_mtdc@fs.fed.us

For further technical information, contact Dick Karsky at the address above.
Phone: (406) 329-3921
Fax: (406) 329-3719

E-mail: rkarsky@fs.fed.us